Chapter Three:

How well do Passive Alcohol Sensors Perform? Are they "Accurate?"

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Performance of Passive Alcohol Sensors

WisDOT, Division of State Patrol, Chemical Test Section Evaluation

The following is a summary of the Chemical Test Section's Evaluation of six passive alcohol sensors currently marketed in the United States. A copy of the full report can be found in Appendix A

An evaluation of passive alcohol sensing devices marketed in the United States was undertaken by the Chemical Test Section to test their performance under both laboratory and controlled drinking settings. Professional contacts and a search of the Internet yielded a list of six manufacturers conducting business in the United States. These six manufacturers were contacted to determine their willingness to participate in the study. Each of the contacted manufacturers agreed to participate and provided a single device for evaluation for the duration of the study. Each device was shipped to the State Patrol, Chemical Test Section with pertinent documentation including technical data sheets, training videotapes, manuals, etc. Testing was conducted from May through October 2002 by the Section chemist and other Section staff. Section staff was trained by the Chemist in the proper use of each device prior to testing.

General operation of a passive alcohol sensor consists of pointing or directing its sampling port to a subject's mouth from a distance that varies by manufacturer. Depending on the device, the operator instructs or encourages the subject to breathe, blow or speak at the device while an air sample is obtained. The analytical method employed by the devices to detect ethanol is the fuel cell, which is common to other breath alcohol testing devices used in Wisconsin including preliminary breath tests (PBT) and the Intoximeter EC/IR, the State's current evidential breath testing device. The fuel cell then analyzes the sample, quickly providing a result in the form of either a numerical readout, indicator lights which display zero, low, or high amounts of alcohol, or a 'P' (Pass) / 'F' (Fail) display indicating the absence or presence of alcohol, respectively. According to manufacturers' literature, each of the devices are ready for a subsequent test within two to thirty seconds after a negative air sample and within twenty seconds to two minutes after an alcohol-laden air sample is tested.

PERFORMANCE TESTING IN THE LABORATORY

Accuracy testing was conducted in the Section laboratory under tightly controlled conditions. Single analyses of simulated breath at six breath alcohol concentrations: 0.00, 0.02, 0.04, 0.08, 0.10, and 0.20 g/210L, using characterized breath alcohol simulator solutions were tested. These breath alcohol concentrations represent important statutory benchmarks and breath concentrations commonly encountered in traffic enforcement. Human breath was blown into the inlet port of the simulators to

produce the samples and towards each passive alcohol sensor from distances of 1, 4, 6, 12, and 18 inches

See Table 1, which contains the results of the testing showing how predictably the passive alcohol-sensing device could detect alcohol in the simulated breath presented to it from five different distances.

Test Results: Performance Testing in the Laboratory

Result: **All passive alcohol sensors tested detected alcohol more than 80% of the time in simulated breath at six inches or less.** Five of the six devices detected alcohol 100% of the time when alcohol-containing breath was presented to the device at 6 inches or less. Performance at longer distances decreased so that at 18 inches only one-half of the units could detect alcohol 80% of the time or more. No passive alcohol sensor manufacturer studied recommends passive alcohol sensor use further than 10 inches from a subject in question. Five of the six passive alcohol sensors properly detected alcohol in simulated breath, when samples were obtained within the manufacturers recommended distances.

See Table 2, which is a summary of the performance of the device when presented with simulated alcohol breaths containing differing breath alcohol concentrations.

Result: **False positives were evident with only one device.** The other five passive alcohol sensors correctly detected no alcohol when alcohol-free simulated breath was presented.

Result: **All devices detected simulated breath alcohol in concentrations of 0.02 - 0.04 g/210L between 60-100% the time.** Performance improved as the concentration of alcohol in the simulated breath increased. Five of the six passive alcohol sensors could detect simulated breath alcohol concentrations of 0.08 g/210L and greater.

Table 1
PASD Detection of Simulated Breath Alcohol at Five Distances

Device	1 inch	4 inches	6 inches	12 inches	18 inches
QuickDraw	100.0%	100.0%	*100.0%*	*80.0%*	*60.0%*
Alcoscan	100.0%	100.0%	100.0%	*60.0%*	*20.0%*
FC10Plus	100.0%	100.0%	*100.0%*	*80.0%*	*100.0%*
AlcoBlow	100.0%	*100.0%*	*100.0%*	*100.0%*	*80.0%*
Alcotest	100.0%	100.0%	100.0%	80.0%	60.0%
PAS III	*83.3%*	*100.0%*	100.0%	*83.3%*	*100.0%*

Shaded area denotes outside of manufacturers' recommendations for use.

Table 2
PASD Detection of Six Simulated Breath Alcohol Concentrations

Device	0.00	0.02	0.04	0.08	0.10	0.20
QuickDraw	100%	60%	80%	100%	100%	100%
Alcoscan	100%	60%	60%	80%	80%	100%
FC10Plus	100%	80%	100%	100%	100%	100%
AlcoBlow	100%	80%	100%	100%	100%	100%
Alcotest	100%	60%	80%	100%	100%	100%
PAS III	*40%*	100%	100%	100%	100%	100%

Shaded area denotes solution containing no ethanol identified as alcohol.

CONTROLLED DOSING STUDY

Controlled dosing (i.e. drinking subject testing) was performed with each passive alcohol sensors in conjunction with routine Breath Examiner Specialist Training. Breath Examiner Specialist Training provides instruction to law enforcement personnel in the proper operation of the Intoximeter EC/IR, Wisconsin's evidential breath alcohol testing instrument. Passive alcohol sensing device operators included Section personnel who had been trained by the Section Chemist in the manufacturers' procedures for routine use (detailed information about the Chemical Test Section's analysis involving controlled dosing tests can be found in Appendix A of this final report).

The study's volunteer subjects were law enforcement officer training participants, who as a routine part of their instruction, volunteered to drink alcoholic beverages thereby providing drinking subjects for non-drinking breath examiner specialists in training. Device operators were Chemical Test Section personnel, trained in the manufacturers' procedures for routine use. Volunteers were provided sufficient alcohol, consumed in one hour, to achieve a maximum breath alcohol concentration of 0.10 g/210L, and were under close supervision by Section personnel. EC/IR breath alcohol concentrations of the subjects averaged 0.045 g/210L (range 0.00 to 0.09 g/210L). Results from the passive alcohol sensors were compared to evidential breath alcohol tests taken within 15 minutes.

Test Results: Controlled Dosing Study

Table 3 summarizes performance of passive alcohol sensing devices versus contemporaneous Intoximeter EC/IR tests on volunteer drinking subjects when used at five different distances. Graphs 1-6 summarize individual performance of each passive alcohol sensor in comparison to contemporaneous Intoximeter EC/IR tests at all distances studied (see Appendix A).

Result: **The data show that when passive alcohol sensors were used at distances greater than one inch, one-half or more of them failed to detect breath alcohol more than 80% of the time.**

Result: **Operation of the devices at 12 inches yielded only one device with a greater than 50% chance of detecting alcohol in known drinkers.**

Result: **When used at the manufacturers recommended operational distances, only two devices, detected alcohol in more than eighty percent of the drinking subjects.**

Result: **Passive alcohol sensing devices have poor *quantitative* abilities.**

Result: **Data in this study confirm that the ability of passive alcohol sensors to measure a coexisting breath alcohol concentration is *poor*. For example, the sensors cannot tell if a person testing positive on the device has a breath alcohol concentration of 0.01 or 0.10g/210L.**

Table 3

PASD vs Intoximeter EC/IR with Drinking Subjects

Device	1 inch	4 inches	6 inches	12 inches	**Average***	**Alcohol-free breaths****
QuickDraw	100.0%	88.9%	*82.1%*	*70.0%*	86.0%	100.0%
Alcoscan	96.6%	85.2%	71.4%	*42.9%*	79.5%	100.0%
FC10Plus	90.3%	79.4%	*71.9%*	*29.4%*	76.5%	100.0%
AlcoBlow	100.0%	*79.4%*	*21.9%*	*0.0%*	63.2%	100.0%
Alcotest	88.2%	31.3%	6.3%	6.3%	45.1%	100.0%
PAS III	*95.2%*	*90.5%*	68.2%	*18.2%*	77.9%	100.0%

Shaded area denotes outside of manufacturers' recommendations for use.

* Includes alcohol-free breaths

**At manufacturer's recommended distance

ACTIVELY DRINKING SUBJECTS

Additional drinking subject testing was conducted during the dosing period after observing a 5-minute alcohol deprivation period to evaluate passive alcohol sensor performance in the presence of moderate amounts of mouth alcohol. A average of 30 subjects were tested on each passive alcohol sensor in this manner, using the manufacturers recommended testing distances or 4 inches where no recommendation was made.

Test Results: Actively Drinking Subjects

Result: **Five out of six of the passive alcohol sensors detected the presence of alcohol in 80% or more of the subjects tested.** The sixth passive alcohol sensor, detected only 45% percent of drinking subjects. Measurements of the subjects' actual breath alcohol concentrations were not possible in this part of the study due to the probability of mouth alcohol in the subjects, and no data was collected on alcohol-free subjects with only mouth alcohol.

Result: **Passive alcohol sensors detect alcohol more readily on persons who have recently been drinking.** The presence of alcohol in drinking subjects increases the ability of the passive alcohol sensor to detect alcohol, regardless of the source.

Result: **Due to the nature of the sampling mechanisms of the devices, the *source* of any alcohol detected cannot be known with complete certainty.**

OPEN CONTAINER TESTING

Open container testing was conducted on each passive alcohol sensor (more detailed information about the Chemical Test Section's analysis involving open container testing can be found in Appendix A of this final report).

Samples of headspace air from open beverage containers were analyzed on each passive alcohol sensor over three, two-day periods in conjunction with routine Breath Examiner Specialist Training. Alcoholic beverages tested included brandy, vodka, rum, and flavored vodkas. These were mixed with sodas (Pepsi Cola, Coca-Cola, RC Cola, 7-Up, Sprite, Sierra Mist, Barq's Root Beer) in diet and regular formulations, lemonade, orange and cranberry juices, or consumed without a mixer. Eighty-two percent of the beverage containers tested contained ice cubes. Passive alcohol sensor operators positioned the devices, on average, 3.4 inches (range 1-11) above the liquid surface for testing. The actual alcohol concentration of drinks being tested was not determined.

Test Results: Open Container Testing

Result: **Passive alcohol sensing devices vary widely in their ability to detect alcohol in beverages.** Four of the six passive alcohol sensors detected alcohol in more than eighty percent of the drinks that contained alcohol. The other two passive alcohol sensors detected alcohol in less than half the beverages containing alcohol. (please see Graph 8: Detection of Alcoholic Beverages).

Result: **"Non-alcoholic beverages can test positive on passive alcohol sensors.** The Chemical Test Section study included open container testing on a limited number of "non-alcoholic" beverages including Sprite, Pepsi, Mountain Dew, Coca-Cola, Diet Coke with lemon and orange juice. The results indicated that there are trace amounts of alcohol in these "non-alcoholic" beverages that can be detected by passive alcohol sensors. Other published studies on ethanol content of soft drinks and other beverages (that an average person would not expect to contain alcohol) are consistent with the Section's test results. These study results strongly suggest that individuals relying on passive alcohol sensors be aware of these findings. In addition, further testing of "non-alcoholic" beverages is recommended prior to selecting a passive alcohol sensor for open container testing.

Overall Results

Testing results from both human testing (i.e. controlled dosing, active drinking subjects) and laboratory testing, indicate two comprehensive results:

Result: **To ensure the best performance from passive alcohol sensors, they must be operated according to manufacturers' recommendations and must be part of a training program on their proper use.** Each sensor requires regular quality control checks, periodic calibration, and occasional replacement of batteries and fuel cells. The sensor users must also be trained in not only the proper use of sensors during a traffic stop, but also in the procedures for ensuring the analytical integrity of the devices through proper and regular maintenance.

Result: **The performance of the passive alcohol sensors diminished from the laboratory setting, to more "real world" controlled dosing studies.** Care must be taken when further extrapolating these test results to a less-than-optimal field environment where carefully controlled conditions do not exist. Conditions that can affect the performance of the sensors include the level of training of officers/users, environmental conditions such as cold and wind, the level of cooperation of subjects, and adherence to a periodic device accuracy monitoring program.

Additional National Studies Focusing on the Performance of Passive Alcohol Sensors

The following provides citations on additional laboratory studies conducted on passive alcohol sensors in other states *in addition to* the more recent laboratory investigations conducted by the Division of State Patrol, Chemical Test Section in 1994 and 2002.

***Cammisa, M.X.; Ferguson, S.A.; and Wells, J.K. 1996. Laboratory evaluation of PAS III sensor with new pump design. Arlington, VA: Insurance Institute for Highway Safety.**

The authors report results of an evaluation of a new version of the PAS III sensor with an improved pump and compare their results with a study conducted earlier by Lestina and Lund (see below) on an older version of the PAS III. Improved performance at greater test distances were reported. The PAS III is expected to correctly identify more subjects having a 0.10 percent BAC at a 10 inch test distance that the previous design did at 5 inches, with a reduction in the percentage of lower BAC subjects misidentified as having a high BAC. Expected detection rates for the PAS III were also calculated for BACs of 0.15, 0.10, 0.08, 0.05, and 0.02 percent. The PAS III achieved its best discrimination of drinking subjects at 0.10 and 0.02 percent BAC when held at a distance of five inches. A second study concludes that equivalent results can be obtained under laboratory conditions even with inexperienced sensor operators.

***Fiorentino, D. 1997. A laboratory study of passive alcohol sensors. Proceedings of the]4th International Conference on Alcohol, Drugs, and Traffic Safety (ed. Mercier-Guyon, C.), 539-45. Annecy, France: Centre d'Etudes et de Reserches en Medecine du Traffic (CERMT).**

Three passive alcohol sensors were studied with drinking subjects to examine the accuracy of the devices as a function of BrAC and measurement distance. Results indicate that if no alcohol is present in an individual's breath, the probability of a PAS's positive BrAC reading is zero. If alcohol is present, a PAS is more likely to underestimate than overestimate that individual's BrAC. Three inherent limitations of sampling ambient air are identified which make PAS suitable for detection but not precise BrAC measurement.

***Lestina, D.C. and Lund, A.K. 1992. Laboratory evaluation of two passive alcohol sensors. Journal of Studies on Alcohol 53:328-34.**

The National Patent Analytical Systems (NPAS) passive alcohol sensor and the Life-Loc PBA 2000 were evaluated in a laboratory environment to establish appropriate threshold measurements that indicate probable alcohol impairment. Both sensors were able to identify alcohol in exhaled breath with sufficient accuracy to identify people with high BACs. The performance of both sensors was related to the distance from

the subject's mouth. Under ideal laboratory conditions, the authors estimated that the Life-Loc could be expected to correctly detect 80 percent of drivers with 0.10 percent BACs (99 percent with 0.15 percent BACs) yet correctly identify only about one in eight drivers with 0.02 percent BACs as being impaired. The NPAS could be expected to correctly detect about 75 percent of drivers with 0. 10 percent BACs (97 percent with 0. 15 percent BACS) but correctly identifying only one in five drivers with 0.02 percent BACs.

Maryland State Police Experience

The Wisconsin State Patrol contacted the Maryland State Police in November 2002. The Maryland State Police indicated that a study that considered using passive alcohol sensors was discontinued pending the development of minimum standards/specifications and an approved product list by the U.S. Department of Transportation. Because this guidance was not developed, the Maryland State Police did not purchase any passive alcohol sensors and the devices have not been utilized.

Virginia State Police Experience

The Virginia State Police evaluated the reliability and practical usage of passive alcohol sensors in the early 1990s. Several devices were assigned to Troopers for use in their OWI enforcement efforts. According to W. Ken Paul, Director of Training for the Virgina State Police, the sensors utilized at that time were not a success due to observations that the devices were perceived as cumbersome and less reliable than the Trooper's natural senses. [21]

As of November 26, 2002, the Virginia State Troopers are evaluating a passive alcohol sensor manufactured by PAS Systems International. The device has been disseminated to Troopers in the field to provide feedback concerning usefulness, effectiveness, durability, and other attributes, positive or negative, to determine its applicability to OWI enforcement efforts. The anticipated completion date for this evaluation process is May, 2003.

[21] November 26, 2002 Email from W. Ken Paul, Jr. Captain and Director of Training of the Virginia State Police.